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1.0 TESTING, ADJUSTING, BALANCING AND COMMISSIONING REQUIREMENTS

1.1 GENERAL

This section specifies the requirements for all testing, adjusting, balancing and commissioning (TABC) the mechanical works to be carried out under the contract. The objectives of TABC are;

i. To verify the delivered materials are as per approved specification and good physical condition.

ii. To verify the installation works are carried out in accordance with specification and good engineering practises.

iii. To verify the performance in terms of functionality, safety, maintainability and operation ability of the installed equipment/systems meet the specified design intent through a series of tests and adjustments.

iv. To ensure all test result is systematically recorded and verified prior to system commissioning.

TABC works are divided into four stages as the following;

i. Pre Delivery stage.

ii. Delivery stage.

iii. Installation stage.

iv. Functional Performance Test stage.

Contractor shall submit Inspection and Testing Plan (ITP) of TABC works to be carried out in accordance with this specification to Superintending Officer (S.O) for review and approval.

1.2 INSPECTION AND TESTING PLAN (ITP)

ITP shall consist of;

i. List of All TABC Requirement

All TABC works with specific scope and boundaries shall be clearly stated at every stage of TABC works and comply with the regulation of Jabatan Bomba dan Penyelamat Malaysia and document contract. Sample of Inspection and Testing Plan as per Table1.

ii. TABC Work Schedules

TABC work schedules shall be integrated into main project schedules.

iii. Method Statements

TABC method statements shall consists of TABC procedures, responsibility, necessary tools, measuring equipment and accuracy, consumables and acceptance criteria. Type of test required is listed in Schedule of Inspection and Testing.

Method statements and acceptance criteria for all equipment installation stage inspection and functional performance testing shall be endorsed by manufacturer or manufacturer's valid representative.

Acceptance criteria shall be stated as per Schedule of Design Requirements, technical specification or any applicable standards.

ITP shall be updated for any changes and resubmitted to S.O/S.O's representative for approval.

Prior to the commencement of the TABC works as per approved ITP, contractor shall issue Request for Inspection and Testing (RFIT) to the S.O. During the TABC, contractor shall have his supervising foreman and mechanics available to aid in testing and to perform any adjustments as directed. The TABC works shall be carried out under the direction of experienced personnel and witnessed by S.O or S.O's representatives. No subsequent installation works shall proceed without S.O approval of the test result.

Depending on the specific demands of individual installation, S.O's representative may require additional or substitute testing works in regard to any elements in the installation other than those indicated in this specification.

Table 1 : Sample of Inspection and Testing Plan

Stage	Inspection / Test Name	Scope and Boundaries	Responsibility	Method Statement	Test Form No	Expected Date
Pre Delivery Stage	Fan Factory Performance Test	Fan	Manufacturer	SS-ITP-01	SS-01	01 Jan
	Switchboard Factory Test	Fan Switch Board	Manufacturer	SS-ITP-02	SS-02	05 Jan
Delivery Stage	Equipment Verification and Physical Inspection	Equipment	Contractor	SS-ITP-03	SS-03	07 Feb
Installation Stage	Support and Hanger Load Test	Equipment, Ductwork	Contractor	SS-ITP-04	SS-04	15 Mac
	Duct Leak Test	High Pressure Above 450 Pa	Contractor	SS-ITP-05	SS-05	18 Apr
	Cable Continuity and Insulation Test	All LV Cable	Contractor	SS-ITP-06	SS-06	19 Apr
Functional Performance Stage	System Performance Test	Flow	Contractor	SS-ITP-07	SS-07	18 May
	Switchboard and Power Supply Test	Switchboard and Power Supply	Contractor	SS-ITP-08	SS-08	17 Jun

1.2.1 Pre Delivery Stage

Pre-delivery inspection and performance test shall be conducted if stated in the Schedule of Inspection and Testing requirements. These tests may be witnessed by the government's representative if deemed necessary by the S.O. All travelling, food and accommodation cost of government representatives related to witnessed performance test shall be borne separately by the government.

A factory test is understood to mean testing at a dedicated test facility, often at manufacturer's plant or at an independent and accredited test facility and to be agreed by the S.O.

Performance test method statement, test standard and acceptance criteria shall be submitted to S.O for approval prior to such testing. The manufacturer shall conduct the test, passes judgement of acceptance and produces a signed test report. All test report shall be submitted to S.O for approval. Manufacturer shall be responsible for any reworks and adjustment of the equipment if the test results fail to adhere to the agreed acceptance criteria.

1.2.1.1 Fan Factory Performance Test

Performance rating tests on fan unit shall be performed by the manufacturer to verify equipment performance against design specifications and compliance with the specification. Fan performance tests shall include but not limited to the following:

(i) Air flow test

(ii) Fan characteristic/ fan curve Test

(iii) Noise Level Test

1.2.1.2 Switchboard Factory Test

Routine tests on the switchboard shall be carried out before delivery to site. The main circuits and the auxiliary circuits shall be tested to verify dielectric properties with power-frequency test voltage of 2500Vac for 1 minute and insulation resistance under test voltage of 1000V. Routine tests shall include inspection and checking of wiring, electrical continuity of the protective circuits, connections and effectiveness of mechanical actuating elements and interlock. Test Results or Certificate duly certified by Competent Person as in Electricity Regulations 1994 shall be issued for every switchboard supplied and installed.

Type testing for switchboard as per categorization shall be as per Table 2 below:

Table 2 : Type Testing for Switchboard

Category	Current Rating	Registration and type of test report
I	I ≤ 600 A	Suruhanjaya Tenaga
II	600 A ≤ I ≤ 1200 A	Suruhanjaya Tenaga & Partial Type Test in accordance with MS IEC 60439-1 (i) Short Circuit Test (ii) Temperature Rise Test
III	I ≥ 1200 A	Suruhanjaya Tenaga & Full Type Test in accordance with MS IEC 60439-1

1.2.2 Delivery Stage

All incoming material and equipment to site shall be verify by visual inspection, documentation and measurement that delivered items are comply with technical specification, as per approved materials and good physical conditions. Materials delivered to site shall be free from defects and adequately protected against site conditions.

1.2.3 Installation Stage

1.2.3.1 Visual Inspection

List of visual inspection and testing during installation as per Table 3 -

Table 3 :Visual Inspection

Inspection / Test Name	System/Component	Objectives
Support and Hanger	Equipment, Ductwork, etc.	Verify hanger and supports as per drawing and technical specification

List of inspection and testing works during installation as per Table 4;

Table 4 :*Test List in Installation Stage*

Inspection / Test Name	System/Component	Objectives
Duct Leak Test, Duct Flushing	Ductwork	Verify integrity of all duct joints and fittings.
Cabling Insulation Test	Cabling	Verify insulation effectiveness
Cable Continuity Test	Electrical Cabling	Verify cable continuity effectiveness

1.2.3.2 Duct Leak Test

All high pressure ductwork more than 750Pa static pressure shall be subjected to duct leak test procedure and acceptance criteria in accordance with HVAC Air Duct Leakage Test Manual ANSI/SMACNA 016-2012. All duct opening shall be sealed prior to duct leak test. Maximum system leakage shall be limited to 5% of design flow.

1.2.3.3 Cabling Insulation Test

Insulation resistance test shall be performed via a megohmmeter with an acceptable voltage output that recommended by cable manufacturer. Each conductor shall be individually test with all other conductors and shields grounded. Test duration shall be one minute and the resistance value shall be recorded until a steady reading is obtained.

1.2.3.4 Cable Continuity Test

Cable continuity test shall be performed on each power cable by ohmmeter method. Perform an acceptance test on cables, including terminations and joints, after cable system installation and before the cable system is placed into service. In accordance with ANSI/IEEE 400, by means of direct voltage (dc) and recorded in the relevant testing form.

1.2.4 Functional Performance Test

List of functional performance test are as the following. All Functional Performance Test shall commence after all inspection and testing during installation stage has been completed.

1.2.4.1 System Performance Test

Each outlet shall be tested to achieve the required design airflow for normal mode (if applicable) and fire mode.

Smoke spill fan/s shall start and motorised dampers shall open (if applicable) automatically under fire mode.

Manual control of smoke spill system shall be tested for both fire command centre and/or in fan switchboard.

A simulation test shall be carried out using cold smoke (smoke generator). Smoke spill fan/s shall be activating under automatic mode and visibility shall be maintained for evacuation.

1.2.4.2 Switchboard and Power Supply Inspection and Test

List of Switchboard and power supply inspection and test name are listed in Table 5. Detail method statement for testing shall be submitted conforming to the test requirements in this specification. Only competent person as in Electricity Regulations 1994 shall conduct the switchboard testing.

Table 5 : Switchboard and Power Supply Inspection and Test Requirements

Inspection / Test Name	Description
Switchboard General Inspection	• Verify physical switchboard components are as per specification. • Check for tripping setting and system trip • Check for wiring, motor insulation and record data. • Check for cable terminal tightness. • Check for equipment and panel grounding connection. • Check for any sign for cable heating. Cable temperature shall be measured and verify against IEEE standards for temperature rise during full load. • Check for voltmeter, and ammeter function and accuracy record running voltage and ampere. • Check for control circuit function as intended. • Check for contractors, relays, ACB, MCCB, MCB, type, size and ratings as per specification.
Power Supply Test	• Verify that power supply parameters are within permissible range, safety protections are in place and physical condition of switch board and cabling works are acceptable as per specification and approved shop drawings. • Verify rotation of equipment/phase sequencing according to manufacturer recommendation • Verify phase protection relay installation and function.
Overcurrent and Earth Fault Protection	• Circuit breaker and Earth Fault Protection calibration and discrimination shall be conducted and coordinated between electrical contractors. • Circuit breaker and Earth Fault Protection shall be tested against simulated leakage current. • IDMT tripping delay shall be selected/programmed suitable for equipment starting overloading preventing nuisance tripping during starting.

1.3 COMMISSIONING

Commissioning includes achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.

All completed test forms and test summary shall be submitted to S.O's representative for final review and approval. Having satisfied that all appropriate tests have been conducted and the performance of the installation meet the design objectives; S.O's representative will issue or recommends to the S.O for the issuance of Certificate of Practical Completion (CPC).

1.3.1 Handing Over Documents

After the issuance of Certificate of Practical Completion, contractor shall submit all related project handing over documents as the following;

a) Test Report complete with fully verified Inspection checklist and Test Forms.
b) Defects List
c) Operation and Maintenance Manual which includes
    - *Manual/Standard Operating Procedures*
    - *Preventive Maintenance Schedule and Manual*
    - *Equipment/Product Engineering Data.*
    - *Operation set point (cut in/ cut off fan, flow rate etc)*
    - *Switchboard overload setting and set points*
    - *Contractor and manufacturer contact details*
    - *Circuit Diagrams*
    - *Inventory List*
d) As-Built drawings
e) Schedule of System Familiarization Program to end users

1.3.2 System Familiarization Program

In-class and practical System Familiarization Program shall be conducted to the personnel nominated by S.O within one (1) month of issuance of Certificate of Practical Completion. Program shall focus on:

- Overview of design concept and objectives
- Operation instruction & competency requirement
- Maintenance procedures
- Critical operating parameters monitoring and
- Emergency response & safety procedures.
- Environmental protection procedures.

Contractor shall submit program modules and materials to S.O for approval prior to commencement of training. Particulars of trainee shall be recorded and send to S.O for records.

2.0 TESTING INSTRUMENTS AND ACCESSORIES

The contractor shall provide all necessary testing, calibrating instruments and labour required for the testing, adjusting and commissioning of the smoke spill system installed under the contract.

The contractor shall also allow for any necessary replacement of parts in order to achieve the conditions specified in the drawings and specification. Provisional sum for that purpose is provided in Schedule of Price.

Testing instruments specification shall be but not limited to as per Table 6.

Table 6: Testing Instruments

Measurement	Type	Accuracy
Duct Thickness	Vernier caliper	± 0.01 mm
Ampere	Clamp meter (instantaneous)	*2.0% ± 5 digits (45-65Hz)*
Voltage	Clamp meter (instantaneous)	*1.5% ± 5 digits*
Air Volumetric Flowrate	Air flowhood with digital manometer	Supply and Exhaust: ± 3% of reading
Air Volumetric Flowrate	Anemometer	-
Smoke Simulation	Smoke Generator	-
Electrical Resistance of Insulator	Megohmmeter	-
Cable Continuity	Ohmmeter	-